REMARKS

Status of the Claims

By this amendment, claims 1-5, 7-15, 17-21 and 32-71 are pending in the application. Of these, claims 1, 2, 7, 8, 10-15, 18-21, 32, 33, 37-39 and 41-43 are being amended, and claims 44-71 are being added. Claims 6, 16 and 22-31 are being canceled. The claim amendments and newly added claims are supported by the specification and original claims, and no new matter is being added. Thus, entry of the amendments and claims and reconsideration of the present case is requested.

Restriction Requirement

In response to the restriction requirement, Applicant elects the claims of Group I, drawn to an etching method, as defined by the Examiner, namely claims 1-21 and 32-43, with traverse. Claims 22-31 are being canceled, without prejudice or disclaimer, as being drawn to a non-elected invention.

Specification

The Examiner objected to the specification for improperly claiming priority from itself in the cross-reference section. However, Applicants maintain that the present application does not claim priority from itself, and properly claims priority from the two earlier applications from which it is a continuation-in-part. The first full paragraph on page 1, in the cross-reference section, reads:

No. 09/116,621, entitled "Process for Etching Silicon-Containing Layers on Semiconductor Substrates," filed on July 16, 1998, and U.S. Patent Application No. 08/969,122, entitled

"Self-Cleaning Etch Process," filed on November 12, 1997-both of which are incorporated herein by reference."

Thus, the present application properly claims priority from both of the earlier applications, not itself (S.N. 09/507,629), and the priority claim is proper.

The Examiner further objected to informalities in the specification. Applicants disagree with the Examiner's objection to line 23 on page 16, as the specification is intended to recite a He backside pressure of 12 Torr, not 12 mTorr, as the Examiner suggests. However, the other informalities have been amended in accordance with the Examiner's recommendations. Thus, the objection to the specification is believed to be obviated.

Rejection Under 35 U.S.C. 112, Second Paragraph, of Claims 1, 10, 14, 15, 18 and 33

The Examiner rejected claims 1, 10, 14, 15, 18 and 33 under 35 U.S.C. 112, second paragraph, for "failing to particularly point out and distinctly claim the subject matter which the applicant regards as the invention." This rejection is traversed.

The Examiner rejected claims 1, 14 and 33 for reciting the phrase "substantially similar," because "the phrase is not defined by the claim, the specification does not provide a standard for ascertaining the requisite degree," and the scope would not be obvious to one of ordinary skill in the art. However, the Applicant's maintain that, contrary to the Examiner's assertions, the phrase "substantially similar" is well defined in the specification and claims. For example, the specification states that "the ratio of the fluorine-containing gas to chlorine-containing gas is controlled to provide etching rates for the compositionally different regions that differ by less than 5% -- or that may even be

Furthermore, originally filed claim 5 recites "wherein the substantially similar etch rates are etch rates that vary by less than about 5 ... Thus, the substantially similar etch rates are

clearly defined by the specification and originally filed claims to be etch rates that vary by less than about 5%. Accordingly, the scope of claims reciting the "substantially similar etch rates" would be clear to one of ordinary skill in the art, and these claims are not indefinite under 35 U.S.C. 112, second paragraph.

Furthermore, it should be noted that, contrary to the Examiner's assertions, claim 1 does not recite the phrase "substantially similar." Thus the rejection of this claim for recitation of this phrase is improper, and claim 1 is allowable over 35 U.S.C. 112, second paragraph.

The Examiner rejected claims 10 and 18, as being indefinite for reciting "wherein the volumetric flow ratio of the fluorine containing and chlorine containing gas to the sidewall-passivation gas." These claims are being amended to recite "wherein the volumetric flow ratio of the combined volumetric flow rate of the fluorine-containing and chlorine-containing etching gas to the volumetric flow rate of the sidewall-passivation gas is from 1:1 to about 10:1." Thus, as amended, the claims clearly recite a ratio of the combined flow rate of fluorine-containing and chlorine-containing gas to the flow rate of sidewall-passivation gas, and the claims are allowable over 35 U.S.C. 112, second paragraph.

The Examiner rejected claim 15 for failing to provide sufficient antecedent basis for "polysilicon." Claim 15 has been amended to recite "silicon-containing material" for which proper antecedent basis is provided in claim 14, from which claim 15 depends. Thus claim 15 is allowable over 35 U.S.C. 112, second paragraph.

Rejection Under 35 U.S.C. 102(b) of Claims 1-12, 14-19, 32-34 and 36-42

102(b) as being anticipated by EP 0 200 951 to Chen et al. This rejection is traversed.

Claim 1 is not anticipated by Chen et al because Chen et al does not teach providing a "process gas comprising fluorine-containing etching gas, chlorine-containing etching gas and sidewall-passivation gas ... wherein the volumetric flow ratio of the fluorine-containing etching gas to the chlorine-containing etching gas is from about 2:1 to about 8:1," as recited in the claim. Instead, in the section recited by the Examiner, Chen et al teaches an etchant gas that "includes three major constituents: the etchant gas species, for example, NF or SF ; and inert gas, such as N ; and a polymerizing gas such as CHF " (column 2, lines 5-9), and also that a chlorine containing gas may be added to the etchant gas (column 2, lines 26-28.) However, Chen et al does not teach a volumetric flow ratio of fluorine-containing etching gas to chlorine containing etching gas. Thus, Chen et al fails to teach each and every aspect of the claim, and claim 1 and the claims depending therefrom are not anticipated by Chen et al.

Similarly, claim 14 and the claims depending therefrom are not anticipated by Chen et al because Chen et al does not teach providing "a process gas comprising fluorine-containing gas, chlorine-containing gas and sidewall-passivation gas, the volumetric flow ratio of the fluorine-containing gas to the chlorine-containing gas being from about 2:1 to about 8:1," as recited in the claim.

The Examiner rejected claims 1-3, 5-12, 32-34, and 36-42 under 35 U.S.C. 102(b) as being anticipated by U.S. Patent No. 5,605,601 to Kawasaki. This rejection is traversed.

Claim 1 is not anticipated by Kawasaki because Kawasaki does not teach providing "a process gas comprising fluorine-containing etching gas, chlorine-containing etching gas and sidewall-passivation gas, the sidewall-passivation gas being a gas other than the fluorine-containing etching gas," (emphasis added) as recited in the claim.

(column 2, lines 55-56), wherein the NF is provided because it is "capable of etching both an oxide film and a polysilicon film" (column [illegible], lines 45-47) and because "the nitrogen

atoms adhere to a sidewall of a pattern and forms a nitride film" (column 3, lines 1-2.) Thus, Kawasaki teaches providing a single fluorine-containing gas that also acts as a sidewall-passivation gas, but does not teach providing a separate sidewall-passivation gas in addition to the fluorine-containing etching gas that is a different gas than the fluorine-containing etching gas. Accordingly, Kawasaki does not teach each and every aspect of the claim, and claim 1 and the claims depending therefrom are not anticipated by Kawasaki.

Similarly, claim 32 and the claims depending therefrom are not anticipated by Kawasaki because Kawasaki does not teach providing "a first process gas comprising fluorine-containing etching gas, chlorine-containing etching gas and sidewall-passivation gas, the sidewall-passivation gas being a gas other than the fluorine-containing etching gas," as recited in the claim.

The Examiner rejected claims 1, 2, 6-11, 14 and 16-19 under 35 U.S.C. 102(b) as being anticipated by U.S. Patent No. 5,716,495 to Butterbaugh et al. This rejection is traversed.

Claim 1 is not anticipated by Butterbaugh et al because Butterbaugh et al does not teach providing "an energized gas formed by coupling RF or microwave energy to a process gas," as recited in the claim. Butterbaugh et al teaches "the removal of silicon oxides and other contaminants ... where ultraviolet (UV) light stimulation ... [is] used to etch different forms of silicon dioxide" (column 1, lines 14-18.) Thus, Butterbaugh et al teaches using ultraviolet light for etching, but does not teach energizing a gas by coupling RF or microwave energy to the gas. Accordingly, as Butterbaugh et al fails to teach each and every aspect of the claim, claim 1 and the claims depending therefrom are not anticipated by Butterbaugh et al.

teaching that "the process specifically occurs in the substantial absence of a plasma or plasma products, such as a downstream plasma effluent" (column 6, lines 29-31.) Thus

Butterbaugh teaches against forming a plasma of a process gas, and teaches against coupling RF or microwave energy to a gas as recited in the claim.

Similarly, claim 14 and the claims depending therefrom are not anticipated by Butterbaugh et al because Butterbaugh et al does not teach providing "an energized process gas formed by coupling RF or microwave energy to a process gas," as recited in the claims.

The Examiner rejected claims 1-5, 7-9, 11, 14, 15, 17 and 19 under 35 U.S.C. 102(b) as being anticipated by U.S. Patent No 4,992,134 to Gupta et al. This rejection is traversed.

Claim 1 is not anticipated by Gupta et al because Gupta et al does not teach providing "a process gas comprising fluorine-containing etching gas, chlorine-containing etching gas and sidewall-passivation gas," as recited in the claim. Instead, Gupta et al teaches providing a halogen-containing fluid, wherein "the halogen-containing fluid may comprise any of the well-known chlorine-and fluorine-containing fluids, such as Cl_2, $SiCl_4$, CCl_4, SF_6, and halogenated hydrocarbons containing one or more fluorine atoms" (column 2, lines 42-45). In other words, Gupta et al teaches providing a halogen-containing fluid comprising <u>either</u> a chlorine containing gas, such as Cl_2, $SiCl_4$, CCl_4, <u>or</u> a fluorine-containing gas, such as SF_6. Gupta et al does not teach providing a process gas comprising fluorine-containing gas <u>and</u> chlorine-containing gas. Thus, Gupta et al does not teach the recited process gas composition, and claim 1 and the claims depending therefrom are not anticipated by Gupta et al.

Similarly, claim 14 and the claims depending therefrom are not anticipated by Gupta et al because Gupta et al does not teach providing a "process gas comprising

the claim.

Rejection Under 35 U.S.C. 103(a) of Claims 13 and 43

The Examiner rejected claims 13 and 43 under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 5,605,601 to Kawasaki. This rejection is traversed.

Claim 1, from which claim 13 depends, is not obvious over Kawasaki because Kawasaki does not teach or suggest providing "a process gas comprising fluorine-containing etching gas, chlorine-containing etching gas and sidewall-passivation gas, the sidewall-passivation gas being a gas other than the fluorine-containing etching gas." As discussed above, Kawasaki teaches providing Cl_2 and NF_3 to etch a substrate. Thus, Kawasaki does not teach providing a sidewall-passivation gas that is other than the fluorine-containing etching gas. Furthermore, Kawasaki teaches that the NF_3 is provided because "in etching, the nitrogen atoms adhere to a sidewall of a pattern and forms a nitride film" (column 3, lines 1-2). Thus, Kawasaki teaches that the NF_3 is sufficient to passivate the sidewall, thus teaching against providing a sidewall-passivation gas in addition to a fluorine-containing etching gas. Given Kawasaki's teachings of the sufficiency of the passivating capacity of NF_3 alone, it would not be obvious to one of ordinary skill in the art to provide a separate sidewall-passivation gas that is different than the fluorine-containing etching gas. Thus, as Kawasaki fails to teach or suggest the process gas of claim 1, claim 1 and the claims depending therefrom are patentable over Kawasaki.

Similarly, claim 32, from which claim 43 depends, is not obvious over Kawasaki because Kawasaki does not teach or suggest "a first process gas comprising fluorine-containing etching gas, chlorine-containing etching gas and sidewall-passivation gas, the sidewall-passivation gas being a gas other than the fluorine-containing etching gas," as recited in the claim.

Objected to Claims

The Examiner objected to claims 20, 21 and 35 as being dependent upon rejected claims, but indicated they would be allowable if re-written in independent form including all of the limitations of their base claim and any intermediate claims

Claims 20 and 35 have been re-written in independent form as newly added claims 44 and 47, including many of the limitations of their base claim and intermediate claims. These claims and the claims depending therefrom are believed to be allowable.

CONCLUSION

The above-discussed amendments and remarks are believed to place the present application in condition for allowance. Should the Examiner have any questions regarding the above remarks, the Examiner is requested to telephone Applicant's representative at the number listed below.

Respectfully submitted,

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MARKED-UP SPECIFICATION FOR S/N: 09/507,629

One page 8, second full paragraph

An energized gas or plasma is generated from the process gas by a gas energizer 46 that couples electromagnetic energy, such as RF or microwave energy, to the process gas in the process zone 30 of the chamber 28, such as for example, an inductor antenna 48 comprising one or more coils powered by an antenna power supply 50 that inductively couples RF energy to process gas in the chamber 28. In addition or as an alternative chamber design, a first process electrode 51 such as an electrically grounded sidewall or ceiling of the chamber 28 and a second electrode 52 such as an electrically conducting portion of the support 32 below the substrate [20] 24 may be used to further energize the gas in the chamber 28. The first and second electrodes 51, 52 are electrically biased relative to one another by an RF voltage provided by an electrode voltage supply 54. The frequency of the RF voltage applied to the inductor antenna 48 and/or to the electrodes 51, 52 is typically from about 50 KHz to about 60 MHz.

In the paragraph bridging pages 8 and 9:

The chamber 28 further comprises a process monitoring system 56 to monitor the process being performed on the substrate [20] 24. The process monitoring system 56 may monitor, for example, an emission from a plasma generated inside the chamber 28, the plasma emission being generally multispectral, i.e., providing radiation having multiple wavelengths extending across a spectrum. In addition, quartz crystal microbalance (QCM) 58 may be used to determine the amount of etchant residue deposited on chamber surface during the etching process. Generally, the microbalance 58 is a piezoelectric plate that changes capacitance when etchant residue is deposited on the plate. The microbalance 58 is mounted on an internal surface in the chamber 28, such as a

In the paragraph bridging pages 11 and 12:

The process sequencer program 134 comprises program code to accept the chamber type and set of process parameters from the process selector program 132 and to control operation of the chamber 28. The sequencer program 134 initiates execution of the process set by passing the particular process parameters to a chamber manager program 136 that controls multiple processing tasks in a chamber 28 and typically includes a process chamber program 124 and a process monitoring program 126. The process chamber program 124 includes program code to set the timing, gas composition, gas flow rates, chamber pressure, chamber temperature, RF power levels, support position, heater temperature, and other parameters of a particular process. Typically, the process chamber program 124 includes a substrate positioning program 138, a gas flow control program 140, a gas pressure control program 142, a gas energizer control program 144, and a substrate temperature control program 146. Typically, the substrate positioning program 138 comprises program code for controlling chamber components that are used to load the substrate 24 onto the support 32 and optionally, to lift the substrate 24 to a desired height in the chamber 28 to control the spacing between the substrate 24 and the gas outlets 38 of the gas delivery system 34. The gas flow control program 140 has program code for controlling the flow rates of different constituents of the process gas. The gas flow control program 140 may also control the open/close position of the safety shut-off valves, and ramp up/down the gas flow controller 40 to obtain the desired gas flow rate. For example, the gas flow control program 140 may be used to set the flow rates of the different gases or to exclude particular gases from the gas composition. The pressure control program 142 comprises program code for controlling the pressure in the chamber 28 by regulating the aperture size of the throttle valve 44 in the exhaust system 42. The gas energizer control program 144 comprises program code for setting low and high-frequency RF power levels applied to the process electrodes 51, 52. Optionally, the substrate temperature control

(not shown) used to heat the support 32 and substrate [20] 24, or the flow rate and temperature of fluid circulated through the support 32.

On page 12, first full paragraph:

The process monitoring program 126 comprises program code that obtains sample or reference signals from the chamber 28 and processes the signal according to preprogrammed criteria. The program 126 may also send instructions to the chamber manager program 136 or other programs to change the process conditions or other chamber settings. For example, the process monitoring program 126 may comprise program code to analyze an incoming signal trace provided by the process monitoring system 56 and determine a process endpoint or completion of a process stage when a desired set of criteria is reached, such as when an attribute of the detected signal is substantially similar to a pre-programmed value. The process monitoring program 126 may also be used to detect a property of a material being processed on the substrate 24, such as a thickness, or other properties, for example, the crystalline nature, microstructure, porosity, electrical, chemical and compositional characteristics of the material on the substrate 24. Upon detecting an onset or completion of a process, the process monitoring program signals the process chamber program 126 which sends instructions to the controller 100 to change a process condition in a chamber 28 in which the substrate [20] 24 is being processed. The controller 100 is adapted to control one or more of the gas delivery system 34, plasma generator 46, or throttle valve 44 to change a process condition in the chamber 28 in relation to the received signal.

In the paragraph bridging pages 12 and 13:

Referring to Figure 1, the data signals received by and or evaluated by the controller 100 may also be sent to a factory automation host computer 300. The factory automation host computer 300 may comprise a host software program 302 that evaluates data from several platforms or chambers 28, and for batches of substrates [20] 24 or over

processes conducted on the substrates [20] 24, on a property that may vary in a statistical relationship across a single substrate [20] 24, or on a property that may vary in a statistical

relationship across a batch of substrates [20] 24. The host software program 302 may also use the data for ongoing in-situ process evaluations or for the control of other process parameters. A suitable host software program comprises a WORKSTREAM™ software program available from aforementioned Applied Materials. The factory automation host computer 300 may be further adapted to provide instruction signals to (i) remove particular substrates 24 from the processing sequence, for example, if a substrate property is inadequate or does not fall within a statistically determined range of values, or if a process parameter deviates from an acceptable range; (ii) end processing in a particular chamber 28, or (iii) adjust process conditions upon a determination of an unsuitable property of the substrate 24 or process parameter. The factory automation host computer 300 may also provide the instruction signal at the beginning or end of processing of the substrate 24 in response to evaluation of the data by the host software program 302.

In the paragraph bridging pages 15 and 16:

Table III shows the polysilicon etch rate and the etch rate uniformity for examples 5 to 17 for etching blanket undoped polysilicon on a silicon substrate in a DPS chamber. The process variables included gas pressure (4, 12 or 20 [Torr] mTorr), source power (600 or 800 watts), bias power (70 or 100 watts), CF_4 flow rate (50 or 100 sccm), and Cl_2 flow rate (0, 10, 20, 40 or 100 sccm). It is seen that the optimal etch rate and uniformity was at about 10:1 to 3:1 volumetric flow ratio of CF_4 to chlorine.

In the paragraph bridging pages 16 and 17:

As shown in Figure 4, the addition of a Cl_2 to a CF_4 based gas chemistry that is absent HBr had a significant effect on the polysilicon etch rate and uniformity. The bars [represents] represent the etch rate uniformity and the line represents the etch rate. This

watts, the bias power at 100 watts, and the helium backside gas pressure maintained at 12 Torr. Adding 20 sccm of Cl_2 in 100 sccm of CF_4 increased the polysilicon etch rate nearly

70%, and improved uniformity from greater than 5 (1δ) to less than 2 (1δ). However, further increasing the Cl_2 flow to 40 sccm did not change the etch rate but degraded etch rate uniformity back to about 5 to 6. These results indicate that a balanced CF_4 to Cl_2 ratio provides both high etch rates as well as good etching uniformity. The optimal gas ratio also depends on the gas composition. Good etch rate uniformity can be obtained with CF_4:Cl_2 gas ratio ranging from 1:1 to 5:1 at 4mTorr, while the gas ratio was limited to around 5:1 at a higher pressure of 12mTorr. At higher gas pressure, source power became a dominating factor in uniformity control, with improved uniformity at a high source power.

On page 18, Table V:

Table V

Pressure mTorr	Source power watts	Bias power watts	CF_4 sccm	Cl_2 sccm	N_2 sccm	Backside He pressure Torr	Cathod temp	Wall temp	Dome temp
4	450	70	100	20	30	6	50	80	80

MARKED-UP CLAIMS FOR S/N: 09/507,629

1. (amended) A method of etching a silicon-containing material on a substrate, the method comprising:

placing the substrate in a process chamber; and

providing in the process chamber, an energized gas formed by coupling RF or microwave energy to a process gas comprising fluorine-containing etching gas, chlorine-containing etching gas and sidewall-passivation gas, the sidewall-passivation gas being a gas other than the fluorine-containing etching gas, wherein the volumetric flow ratio of the fluorine-containing etching gas to the chlorine-containing etching gas is from about 2:1 to about 8:1.

2. (amended) A method according to claim 1 wherein the silicon-containing material on the substrate comprises regions having different compositions, and wherein the volumetric flow ratio of the fluorine-containing etching gas, chlorine-containing etching gas, and sidewall-passivation gas is selected to etch the regions having different compositions at substantially similar etch rates.

7. (amended) A method according to claim 1 wherein the fluorine-containing etching gas comprises one or more of NF, CF, or SF.

8. (amended) A method according to claim 1 wherein the chlorine-containing etching gas comprises one or more of Cl or [Hcl] HCl.

10. (amended) A method according to claim 9 wherein the volumetric flow ratio of the combined volumetric flow rate of the fluorine-containing and chlorine-containing etching gas to the volumetric flow rate of the sidewall-passivation gas is from 1:1 to about

11. (amended) A method according to claim 1 wherein the [energized] process gas is absent HBr, Br_2 or CH_3Br.

12. (amended) A method according to claim 11 further comprising a second etch step in which [a second] an energized gas formed from a second process gas comprising HBr is provided in the process chamber.

13. (amended) A method according to claim 12 wherein the second [energized] process gas further comprises one or more of Cl_2, He-O_2 and CF_4.

14. (amended) A method of etching a substrate in a process chamber while simultaneously cleaning surfaces in the process chamber, the method comprising:

placing the substrate in the process chamber, the substrate comprising a silicon-containing material having a plurality of dopant concentrations or dopant types; and

providing in the process chamber, an energized process gas formed by coupling RF or microwave energy to a process gas comprising fluorine-containing gas, chlorine-containing gas and sidewall-passivation gas, the volumetric flow ratio of the fluorine-containing gas to the chlorine-containing gas being from about 2:1 to about 8:1, whereby the plurality of dopant concentrations or dopant types in the silicon-containing material[ ] are etched at substantially similar rates.

15. (amended) A method according to claim 14 wherein the volumetric flow ratio of the fluorine-containing gas, chlorine-containing gas and sidewall-passivation gas, is selected to etch the plurality of dopant concentrations or dopant types in the [polysilicon] silicon-containing material at etch rates that vary by less than about 5%.

flow ratio of the combined volumetric flow rate of the fluorine-containing and chlorine-

containing etching gas to the volumetric flow rate of the sidewall-passivation gas is from about 1:1 to about 10:1.

19. (amended) A method according to claim 18 wherein the [energized] process gas is absent HBr, Br_2 or CH_3Br.

20. (amended) A method according to claim 19 further comprising a second etch step in which [a second] an energized gas formed from a second process gas comprising HBr is provided in the process chamber.

21. (amended) A method according to claim 20 wherein the second [energized] process gas further comprises one or more of Cl_2, He-O_2 and CF_4.

32. (amended) A method of etching a silicon-containing material on a substrate, the method comprising:

placing the substrate in a process chamber;

in a first etching stage, providing in the process chamber, [a first] an energized gas formed from a first process gas comprising fluorine-containing etching gas, chlorine-containing etching gas and sidewall-passivation gas, the sidewall-passivation gas being a gas other than the fluorine-containing etching gas, the first [energized] process gas being absent HBr, Br_2 or CH_3Br; and

in a second etching stage, providing in the process chamber, [a second] an energized gas formed from a second process gas comprising HBr, Br_2 or CH_3Br.

33. (amended) A method according to claim 32 wherein the silicon-containing material on the substrate comprises regions having different compositions, and wherein the first [energized] process gas comprises a volumetric flow ratio of fluorine-

is selected to etch the regions having different compositions at substantially similar etch rates.

37. (amended) A method according to claim 32 wherein the first [energized] process gas comprises a volumetric flow ratio of fluorine-containing etching gas to chlorine-containing etching gas that is from about 2:1 to about 8:1.

38. (amended) A method according to claim 32 wherein the fluorine-containing etching gas comprises one or more of NF, CF_4 or SF.

39. (amended) A method according to claim 32 wherein the chlorine-containing etching gas comprises one or more of Cl or HCl.

41. (amended) A method according to claim 32 wherein the volumetric flow ratio of the combined volumetric flow rate of the fluorine-containing and chlorine-containing etching gas to the volumetric flow rate of the sidewall-passivation gas is from 1:1 to about 10:1.

42. (amended) A method according to claim 32 wherein the second [energized] process gas comprises HBr.

43. (amended) A method according to claim 42 wherein the second [energized] process gas further comprises one or more of Cl, He-O and CF.